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Thurlby

1503 and 1504
high resolution multimeters

MP MASTER
MA24078

INSTRUCTION MANUAL

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1. Introduction (1503, 1503-HA, 1504)

The 1503 is a 4¾ digit (± 32,768 count) manual ranging bench/portable multimeter. It provides high accuracy readings of DC and AC voltage, DC and AC current, resistance, frequency and diode test. Operation is either from AC line power or internally-fitted batteries and the rugged case with tilt stand/handle makes it suitable for bench or field use.

The 1503-HA is a higher accuracy version designed for applications requiring the highest possible levels of accuracy, particularly in the measurement of DC voltage. The operating instructions are identical to those for the standard 1503.

The 1504 has True RMS AC functions in place of the average responding AC fitted to the 1503 and 1503-HA. Operating instructions are as for the standard 1503 apart from section 3.7 (AC measurements).

2. Preparation for use

2.1 Operating Power

The 1503 can be operated either from an ~ AC line adaptor or from internal batteries.

(1) AC line adaptor:- this should be plugged into the 3.5mm socket mounted on the back panel. The adaptor must be of an approved type with an input voltage rating suitable for the line voltage where it is to be used. Output voltage requirement is 9V DC ⎓ nominal at 25mA via 3.5mm jack plug (tip positive).

(2) Batteries:- to install batteries, the instrument should be inverted and the four screws in the feet removed. Turn the instrument the right way up and carefully slide off the top of the case. The battery holder is at the back of the instrument and should be loaded with six C size (U11 size) disposable batteries. Observe correct polarity when inserting the batteries. Further information regarding batteries is given in Section 4.

2.2 Stand

The instrument can be set at various angles using the tilt stand.

3. Operation

The basic sequence of operation for any measurement is as follows:-

(a) Turn on power by depressing the red button.

(b) Select the function either V, Ω or A (depress both buttons together to select A).

(c) Depress the AC~button if AC voltage or AC current measurement is required. Ensure it is released if a DC ⎓ or Resistance measurement is required.

(d) Select a range whose maximum reading is higher than the input you wish to measure.

(e) Connect the source to the input terminals and take the measurement.

⚠ CAUTION Do not exceed the maximum input limits given in Section 3.2. Doing so could damage the instrument

3.2 Maximum Inputs ⚠

Function	Ranges	Max. Input
DC ⎓ V	320mV and 3200mV	250V rms 370V DC
	32V to 1200V	750V rms 1200V DC
AC ~ V	1600mV/3200mV	250V rms 370V DC
	16V/32V to 750V	750V rms 1200V DC 10^6VHz
Ω	ALL	250V rms 370V DC
A	80uA to 800mA	250V rms 370V DC 1 amp
	10A	10A continuous 25A 10secs.
kHz		250V rms 50Hz, 370V DC

Important Note

The input ground socket is electrically connected to the ground of the frequency input socket and to the negative of the AC line adaptor socket. Voltage must not be connected between these points, since passing large currents between them may damage the instrument.

Only use an approved double insulated (not grounded) AC adaptor, and never connect to the frequency input when a connection is still being made to the input ground socket.

3.3 Overrange indication

Where the input exceeds the maximum reading of the range, the display will indicate overrange by showing two zeros with the last zero flashing on and off approximately once per second. Note that resistance ranges will of course always show overrange with no input connected.

3.4 Negative indication

On DC voltage and current ranges, a negative symbol will automatically appear on the left hand side of the display if the red input socket is taken negative with respect to the black (ground) socket.

3.5 Decimal Point Position

The decimal point is automatically positioned to give a direct reading in mV, V, µA, mA, A, Ω, kΩ or MΩ as shown by the range and function buttons. Leading zero blanking is provided for the three most significant digits, consequently a zero reading is shown as 00. or .00 or . 00 depending on range. In the latter case it should be noted that for readings of 99 or less there is a blanked zero to the right of the decimal point. Thus . 83 (V) should be interpreted as .083 volts and not as .83 volts.

3.6 DC ⎓ voltage measurement

The 1503 reads DC voltage between 10uV and 1200V. Maximum displayed reading is ± 32767 except on the highest range. Voltage measurement is selected by depressing the button marked V. Ensure that the button marked AC∼ is released for DC measurement. The input is applied between the red socket marked V-Ω-A, and the black (ground) socket next to it.

The input impedance of all five ranges is 10MΩ. However, if a 10MΩ impedance would cause errors by loading the circuitry, voltages up to ± 3.2 volts can be measured at >1GΩ impedance as follows: Release all the range buttons by half-depressing one of them, then depress the button marked Ω . The meter will now read directly in mV with >1GΩ input impedance. N.B. With no input connect the display will show a random reading.

CAUTION: Observe maximum input voltage limits.

Note: On the most sensitive ranges the input bias current (typically 20pA) will cause an offset to appear when the input is left open circuit (offset = input bias current x 10MΩ). The offset will disappear when the input is connected to a voltage source.

3.7 AC ∼ voltage measurement

The 1503 reads AC voltage between 100uV and 750V. Maximum displayed reading is 16,383 except on the highest range. Voltage measurement is selected by depressing the button marked V. The button marked AC∼ should also be depressed. The input is applied between the red socket marked V-Ω-A and the black (ground) socket next to it.

AC measurements are mean responding, rms calibrated for sinusoidal signals.

CAUTION: Observe maximum input voltage limits.

Note 1: On the 1600mV and 16V ranges, the display may not read zero when the input is left open circuit because of general noise pickup. On the 16V range a small offset may appear even with the input short circuited. This offset will not cause measurement errors at higher levels.

Note 2: The AC ranges do not respond to a DC input. However, if it is required to measure AC superimposed on DC, the sum of the DC level plus AC rms level must not exceed the maximum value of the range. This restriction may be eliminated by placing a capacitor in series with the input.

The 1504 differs from the 1503 in that all AC measurements (including AC current) are True RMS instead of mean responding. In addition, the maximum displayed reading on AC voltage is 32,767 except on the highest range. Maximum crest factor (ratio of AC pk to AC rms) is 5 at 10,000 counts dropping to 1.6 at 32,000 counts.

3.8 Resistance measurements

The 1503 reads resistance between 10mΩ and 32MΩ. Maximum displayed reading is 32,767. Resistance measurement is selected by depressing the button marked Ω. Ensure that the button marked AC∼ is released. The input is applied between the red socket marked V-Ω-A and the black (ground) socket next to it.

CAUTION: Observe maximum input voltage limits.

Note: On the lowest resistance ranges the resistance of the test leads may be significant. Before taking a measurement, the leads should be shorted together and any reading obtained should be subtracted from the measurement reading.

3.9 DC ⎓ or AC∼ current measurements

The 1503 reads DC or AC current from 10nA up to 10 amps (25 amp short term), Maximum displayed reading is ± 8191 except on the 10 amp range. Current measurement is selected by depressing together the buttons marked V and Ω. For AC measurements, the button marked AC∼ should be depressed, for DC measurements it should be released. Inputs up to 800mA should be applied between the red socket marked V-Ω-A and the black (ground) socket next to it. Currents in excess of 1 amp DC or AC rms will cause the fuse located on the back panel to rupture. Inputs up to 10A continuous (or 25 amps for less than 10 seconds) should be connected between the red socket marked 10A and the black (ground) socket on its right. Depress the range button marked 10A to position the decimal point for a direct reading in amps. N.B. If more resolution is needed, pressing the 80μA button will increase the reading by a factor of ten. No fuse is provided for this input.
Where very low currents need to be measured such as for leakage testing, an additional range with 1nA resolution can be obtained by selecting voltage and depressing the 320k and 32M buttons together. This gives a high sensitivity current range that reads directly in microamps.

CAUTION: Observe the maximum input limits.

Note 1: The standard test leads provided are not suitable for currents in excess of 6 amps.
Note 2: The range switches should not be operated when measuring current in a high inductance circuit, since breaking the current path can generate very high voltages.

3.10 Diode test measurements

The 3200Ω resistance range can be used to measure the forward voltage drop of diodes and transistors at a current of 1mA with a direct reading in millivolts. The anode should be connected to the red socket marked V-Ω-A, and the cathode to the black (ground) socket. Each resistance range provides a high precision current source with the output reducing in decade steps. Thus, the 32kΩ range outputs 100uA, 320kΩ -10uA, 3200kΩ - 1uA, 32MΩ - 0.1uA. Maximum output voltage is +5½ volts, but non-linearity commences above 3½ volts.

CAUTION: Observe the maximum input voltage limits.

3.11 Frequency Measurement

The 1503 can measure frequency from 0.1 kHz up to 3,999.9 kHz. Frequency measurement is obtained by plugging a 3.5mm jack plug into the socket marked kHz. This automatically switches the meter from multimeter mode to frequency meter mode regardless of the position of the function button. The range switch marked kHz should be depressed in order to position the decimal point for a direct reading in kHz.
The frequency to be measured should be connected to the 3.5mm jack plug (ground to body). Sensitivity is typically better than 100mV pk-pk. For correct operation the input level should not exceed 6 volts pk-pk.

Although the maximum displayed reading is 3999.9, higher frequencies can be measured by overflowing the display. An input of 5.5436 MHz would give a display of 1543.6 kHz, i.e. 4000 kHz less than the correct reading. The maximum frequency that can be measured in this way is typically 7 MHz, but sensitivity is further reduced above 4 MHz.

N.B. The ground of the frequency input is electrically connected to the black (ground) socket of the V-A-Ω input. Do not connect a voltage between these points because passing a large current between them could damage the instrument.

CAUTION: Observe the maximum voltage input limits.

Note: With no input connected, the display may show a random reading caused by pick-up of spurious signals.

4. Operation from batteries

The 1503 is operated from six disposable C size (U11 size) cells which are fitted as described in section 2.1. With batteries installed, operation from the AC line adaptor is still possible since the batteries are automatically disconnected when the adaptor is plugged in.

The instrument will operate from any type of C cell, but the most appropriate type will depend on the use to which it will be put. Alkaline types (e.g. MN1400) will give the longest battery life - about 200 hours' operation - and may be most suitable if regular portable operation is required. If only occasional portable use is envisaged, however, high power Zinc-Carbon (e.g. HPII) may be preferable because of their lower cost.

4.2 Low battery indication

Indication of a low battery state is provided by an LW symbol on the left of the display. About 10% of total battery life remains when this indication starts, however, the batteries should be replaced as soon as is conveniently possible.

Important Note: Never leave dead batteries in the instrument. Even 'leak-proof' types can leak corrosive fluid which may cause substantial damage.

5. Fuse Replacement

The protection fuse for the current ranges is mounted on the back panel. If blown, it should be replaced with a 20mm quick blow 1 amp H.R.C. fuse. These fuses are often described as 'mains' types, and normally have a ceramic body.

6. Calibration requirements

In order to ensure consistent, accurate measurements, some simple precautions should be followed. Keep the instrument dry, moisture can affect the accuracy. Do not place the instrument on top of equipment that generates heat. Do not subject it to extremes of temperature.

The specifications apply for a period of 12 months. Re-calibration at 12 month intervals is recommended for applications where conformance to original specification is of critical importance.

The manufacturers provide a re-calibration service, as will their agents overseas. Where owners wish to carry out re-calibration themselves, this should only be done by skilled personnel with access to precision equipment working in conjunction with the service manual which may be purchased directly from the manufacturer or their agents overseas.

7. Maintenance and Repair

The manufacturers or their agents overseas will provide repair for any unit developing a fault. Where owners wish to undertake their own maintenance work, this should only be done by skilled personnel in conjunction with the service manual which may be purchased directly from the manufacturers or their agents overseas.

In the U.K., defective instruments should be returned, carriage paid, to the manufacturers' Service Department. Careful and substantial packing is essential - no responsibility can be accepted for damage caused in transit to the manufacturer - if possible, retain the original packing material. If the guarantee has expired or if the fault is the result of misuse, the repair will be carried out and charged unless other instructions are received.

Customers outside the U.K. should contact the dealer from whom the unit was purchased to ascertain service arrangements for that country.

8. Guarantee

The 1503 is guaranteed as free from defects in workmanship or materials. The terms of the guarantee will vary dependent upon the country in which it was sold. Information concerning the guarantee can be obtained from the agent from whom the instrument was purchased.

9. General safety considerations

The 1503 has been designed to the highest safety standards, however, safety depends on the user and the following basic precautions should be followed:-

1. Use only an approved type of double insulated AC line adaptor. The input ground socket is directly connected electrically to the negative side of the AC line adaptor output, so when input ground is raised above true ground this voltage appears on the adaptor.

2. Remove any high voltage input before using the frequency function. The input ground (black) socket is electrically connected to the ground side of the frequency meter socket.

3. Never raise the voltage on the input ground (black) socket more than 500 volts peak above true ground.

4. Never apply a voltage to the input that exceeds the maximum allowable voltage for the range.

5. Never remove the test leads from the instrument whilst they are still connected to a source of high voltage.

6. When working with circuits containing voltages in excess of 40 volts, disconnect connected power from the circuit before connecting test leads.

7. Do not apply voltages in excess of 40 volts to the instrument while the covers are removed.

10. TECHNICAL SPECIFICATIONS

Conversion Speed	V-Ω-A	320msec (3.125 readings/sec)
	Frequency	100msec (10 readings/sec)
Warm-up Time	15 mins from switch-on for full accuracy (19-25°C)	
DC N.M.R.	>60dB at 50Hz, 100Hz, 150Hz	
1k C.M.R.	>100dB AC line essentially infinite on batteries	
Environmental Limits	Operation 0 to 45°C, 0-80% RH up to 30°C Storage −10 to 60°C	
Dimensions and Weights	230x230x60mm, 1.2Kg	
Standards:	IEC 348 Safety classification 2.	

In line with a policy of continuous development, the manufacturers reserve the right to alter specifications without notice.

Accuracy	12 months 19°C-25°C ±(% reading + % full scale)		Temperature coefficient-less than 1/10 th of applicable accuracy specification per °C.
DC Voltage	**1504**	**1503**	**1503-HA**
±320.00mV	0.09%r.+02%fs	0.1%r+.02%fs	0.08%r+.015%fs
±3200.0mV	0.05%r.+.005%fs	0.05%r+.005%fs	0.03%r+.005%fs
±32.000V	0.07%r+.005%fs	0.08%r+.005%fs	0.03%r+.005%fs
±320.00V	0.09%r+.005%fs	0.1%r+.005%fs	0.05%r+.005%fs
±1200.0V	0.1%r+.01%fs	0.1%r+.01%fs	0.05%r+.01%fs

Resistance	1504/1503	1503-HA
320.00Ω	0.15%r+.05%fs	0.15%r+.05%fs
3200.0Ω	0.1%r+.01%fs	0.1%r+.01%fs
32.000k	0.1%r+.005%fs	0.08%r+.005%fs
320.00k	0.1%r+.005%fs	0.08%r+.005%fs
3200.0k	0.2%r+.005%fs	0.15%r+.005%fs
32.000M	0.6%r+.01%fs	0.5%r+.01%fs

AC Voltage	1504 (True RMS)	1503/1503-HA (Average Sense)	
3200.0mV	0.3%r.+.05%fs	1600.0mV	0.2%r+.02%fs
32.000V	0.35%r+.05%fs	16.000V	0.25%r+.02%fs
320.00V	0.35%r+.05%fs	160.00V	0.25%r+.02%fs
750.0V	0.35%r+.2%fs	750.0V	0.25%r+.04%fs

DC Current	1504/1503	1503-HA
±80.00μA	0.2%r+.05%fs	0.15%r+.04%fs
±800.0μA	0.15%r+.02%fs	0.1%r+.015%fs
±8.000mA	0.15%r+.02%fs	0.1%r+.015%fs
±80.00mA	0.15%r+.02%fs	0.1%r+.015%fs
±800.0mA	0.3%r+.02%fs	0.25%r+.02%fs
±10.00A	2.0%r+.1%fs	1.5%r+.1%fs

AC Current	1504(True RMS)	1503/1503-HA (Average Sense)
800.0μA	0.4%r+.2%fs	0.3%r+.04%fs
8.000mA	0.4%r+.2%fs	0.3%r+.04%fs
80.00mA	0.4%r+.2%fs	0.3%r+.04%fs
800.00mA	0.6%r+.2%fs	0.5%r+.04%fs
10.00A	2.5%r+.1%fs	2.5%r+.3%fs

Diode Test	1504/1503/1503-HA	Excitation Current
3200.0mV	0.05%r+.005%fs	1mA

Frequency	1504/1503/1503-HA	Sensitivity typical
4000.0kHz	0.005%r+.0025%fs	100mV pk-pk

Input Impedance - 10MΩ/ /<100pF
Voltage Burden current ranges - 100μV/count, 800mA and 10A 150μV/count

Max. Inputs
Voltage:-320mV, 3200mV - 370Vpk, Other ranges - 1200Vpk
Current:- 1A fused (10A range 25A for 10 secs)
Resistance, Diode Test, Frequency - 370Vpk

AC Functions
Accuracy quoted 45Hz-1kHz current, 45-65Hz voltage

Additional Errors	65Hz – 400Hz	– 5kHz	– 10kHz	– 20kHz
1600mV/3200mV	0.1%	0.2%	0.3%	0.6% (1504)
16V/32V	0.3%	2%	5%	
160V/320V	0.3%	5%		
750V	2%			

AC accuracies apply above 800 counts 45Hz-20kHz, and below 10,000 counts 5kHz - 20kHz.

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